ART. XVI.—*Histology of the Spinal Cord.*

1. *Researches on the Development of the Spinal Cord in Man, Mammalia, and Birds.* By J. LOCKHART CLARKE, F.R.S. From the Philosophical Transactions. Part II., 1862. 4to. pp. 28. With 4 plates.
2. *Notes of Researches on the Intimate Structure of the Brain.* Third Series. By J. LOCKHART CLARKE, F.R.S. From the Proceedings of the Royal Society. Vol. XII., No. 57. 8vo. pp. 7.
3. *A case of rapid "Wasting Palsy" from Structural Disease of the Spinal Cord.* By J. L. W. THUDICHUM, M. D.—*The Investigation of the Nervous Centres with Comments.* By J. LOCKHART CLARKE, F.R.S. From Dr. Beale's Archives of Medicine. No. XIII., 1863. 8vo. pp. 22. With 5 plates.

To Bidder and Kupffer, and still more recently to Kölliker, we are mainly indebted for our knowledge of the histology of the development of the spinal cord in birds and the higher animals. Their investigations have led them to the following results:—

"1. After the closing of the laminæ dorsales, the cord at first consists of a canal, the walls of which are composed of cells of one uniform kind, and disposed in a radiating form.

"2. In the next place, this wall of cells divides into two layers, of which the outer forms the gray substance, while the inner one appears as the lining of the central canal.

"The white substance makes its appearance later than the gray, by the cells of which it is without doubt furnished as an outer layer or covering. The white columns are four in number, two on each side; and to these a white commissure is added. There are no lateral columns; those which are so called are subsequently formed as an extension of the anterior columns."

In the *Philosophical Transactions* for 1859 Mr. Clarke showed that, in the adult spinal cord of man and all vertebrate animals, the white columns as well as the gray substance are everywhere interspersed with granular nuclei, of which some are attached to the sheaths of the primitive nerve-fibres, while others are imbedded in the intervening connective tissue. In the gray substance these nuclei are more abundant than in the white, and have much resemblance to many of the free nuclei or cells, which are certainly in connection with nerve-fibres, and with which they are freely intermixed. To the study of the development of these nuclei Mr. Clarke has devoted much time and attention with the hope of determining the histological relation which they bear to the other elementary tissues of the cord. We could not with advantage to our readers follow him into the minute details of his elaborate researches, without constant reference to the explanatory plates with which the memoir on the spinal cord is illustrated. From the concluding pages of this memoir, however, we borrow the following statements which exhibit in a general manner the conclusions to which our author has been conducted by his admirable labours:—

"We have seen that in its earliest stage of development, the spinal cord consists of a canal surrounded only by one uniform or homogeneous layer of small cells or nuclei, which are not distinguishable from each other in appearance, and

are so closely aggregated as to seem in actual contact. To call this single layer the epithelium of the cord, appears to me about as incorrect as it would be to call the germinal membrane of the ovum the mucous or internal of the two layers into which it immediately separates; for in the second stage of its development, we find that this single and homogeneous layer constituting the entire substance of the cord, while it continues to increase in depth, undergoes a differentiation into two distinct layers—an inner, constituting the true epithelium, and an outer, constituting the gray substance; and although the former does not undergo the histological and morphological changes which subsequently take place in the mucous layer of the germinal membrane, yet it is probable that *after* the production of the outer or gray substance, it differs in its histological character from the originally homogeneous layer. This differentiation of structure proceeds very gradually, and is not at first marked by any decided line of separation, or by any difference in the appearance of the structural elements. At the same time there is gradually formed around, and apparently secreted from, the small cells or nuclei, a granular substance that forms into processes or fibres, and constitutes a continuous network by which all the nuclei or cells of both layers are uninterruptedly connected. In the gray substance itself there is no apparent difference in structure between its anterior and posterior portions, although in each portion darker and more-closely aggregated groups of nuclei may be observed in connection with the roots of the nerves. But as development progresses, a diversity of structure ensues; for while the nuclei of the *posterior* gray substance, although rather more granular than at first, have scarcely advanced in size, those of the *anterior* substance have increased to double their original diameter, and are connected by thicker fibres, which form a coarser and more granular network. At the same time, around the separate groups of the latter substance, the granular network between the nuclei assumes a more sponge-like structure. Meanwhile, within the group, there are formed from the nuclei a number of large, roundish or irregular but adjacent cells, with thick nucleated walls. It is quite evident that the nucleated tissue constituting the walls of these cavities and the network around them is in every respect similar in appearance to that which is very commonly assumed by the connective tissue of parts external to the cord.

"It appears, then, that in these early stages of development there are at least two kinds of free nuclei in the gray substance of the cord. The one kind appear to develop the general network of tissue which pervades the entire structure, but proceed no further; whereas each of the other kind, while connected with this network as well as with nerve-fibres, develops a nucleated cell with a nucleated wall which is still connected, and ultimately blended, with the surrounding reticular structure. In the cells of the intervertebral ganglia, although the process appears to be *essentially* the same, there is some difference in the appearance they present in the earlier stages of development. As development advances, these nuclei or small cells of the intervertebral ganglia simply enlarge, at first, but at the same time are connected with each other and with intervening granular nuclei by fine fibres. At a later period a very distinct and well-defined nucleus, surrounded by a variously-shaped granular mass, makes its appearance within each cell; while its surface becomes the cell-wall, which at first is thin, but gradually increases in thickness. Now the surfaces of these cells are in connection not only with the intervening nucleated fibres which are continuous with the connective tissue forming the sheath of the ganglion, but also with the walls of the adjacent bloodvessels; and it is probably through the medium of this nucleated tissue that the developing cells are supplied with nutritive fluid. Indeed, if we except the muscular fibre-cells, with which some of them are provided, the walls of the bloodvessels are only a part of pia mater and connective tissue between them. On examining the layer of pia mater which immediately surrounds the cord, it may be seen to connect the walls of the bloodvessels which it contains with the sheaths of the intervertebral ganglia, and, through this, with the sheaths of their nerve-cells, on one side, and on the other side with the connective tissue or pia mater within the cord itself. Since the sheaths of the nerve-cells have been shown to be continuous with, and indeed to form a part of, the reticular connective tissue of the cord, which is itself continuous with the pia mater of

the surface, it is evident that the processes of the epithelium, the pia mater and connective tissue within the cord, the walls of the bloodvessels, and the sheaths of the nerve-cells must be all uninterruptedly continuous with each other. But the sheaths of the nerve-cells are certainly connected with the surfaces of their granular contents; and in the fully-developed cord, where the cell-sheaths are much finer and thinner, processes from the cells are continuous by fine subdivisions with the surrounding reticular structure. These observations, then, appear to throw important light on the question which I formerly proposed, as to whether there is any actual and essential difference between the connective and the true nerve tissue, or 'whether the connective tissue of the cord be intermediate in its nature, passing on the one hand into *nerve*-tissue, and on the other into *pia mater*.'[1] We have seen that the cell-sheath or wall is the product of, and indeed is constituted by, the very surface of the primitive nucleus or cell, and that, while it ever after remains in connection with its contents, it forms a part of the surrounding connective tissue, which is itself a prolongation not only of the pia mater of the surface, as well as the walls of the bloodvessels, but also of the processes of the epithelium. But although there is this uninterrupted continuity between all the constituent elements of the cord—although, perhaps, the nerve-tissue actually changes by insensible degrees into the tissues with which it is continuous—and although the cell-wall, which forms part of the surrounding reticular structure, is a product of the primitive nucleus, there is yet no ground for believing that the connective tissue, as such, can ever develop itself into nerve-tissue, any more than that any one of the differentiated parts of a fully-developed organ can reproduce the entire structure; for the nerve-cell, although it develops from itself its own sheath, which forms part of the nucleated connective tissue, produces something more than this tissue, viz., the granular contents of the cell.[2]

"We know that the processes of the nerve-cells constitute the axis-cylinders of the vasomotor nerves distributed to parts external to the cord; and therefore it seems probable that the finer processes which are lost by subdivision in the pia mater or connective tissue within the cord are the means of transmitting nerve-power to that tissue and to the coats of its bloodvessels, from which, by their uninterrupted connection with them, as already shown, the nerve-cells in return receive their supply of nutriment."

The second of the three papers under notice is occupied with an account of the minute anatomy of the cerebral convolutions, the valve of Vieussens, and the cerebellum, together with a description of the course of the fibres of the central white substance of the brain through the convolutions.

The valve of Vieussens, according to Mr. Clarke, consists of four different kinds of layers: 1st, An inferior layer composed of epithelium and continuous with that of the fourth ventricle; 2d, a stratum of longitudinal nerve-fibres, continuous with the white substance of the inferior vermiform process of the cerebellum; 3d, a layer consisting of a multitude of round, granular nuclei of about the 3500th of an inch in diameter, traversed by fibres derived from the subjacent layer; 4th, a superior layer, chiefly granular, but also interspersed with nuclei of the same kind.

Most of the convolutions of the brain consist of eight distinct and concentric layers. The first or superficial layer is a comparatively thin stratum of fine and closely-packed fibres. The second is of a pale or whitish colour, and several times thicker than the first. It is composed of two sets of fibres and a small number of scattered nuclei, which are round, oval, fusi-

[1] Philosophical Transactions, 1859, Part I. p. 442.

[2] There can be no doubt that a considerable proportion of the gelatinous substance and other parts of the posterior cornu are of the nature of pia mater; but amongst this there are numerous small nerve-cells. As I have dwelt, however, on this point in another place (*Phil. Trans.* 1859), I need not repeat my remarks.

form, or angular. The third layer is of a gray colour, from two to four times as thick as the one above it. It is densely crowded with cells of small size, but of different shapes, in company with nuclei like those of the preceding layer. The fourth layer is of a much paler colour. It is crossed, however, at right angles to its plane by narrow, long, and vertical groups of small cells and nuclei of the same general appearance as those of the preceding lamina. These groups are separated from each other by bundles of fibres radiating towards the surface from the central white substance, and, together with them, form a beautiful and fan-like structure. The fifth layer consists of the same kind of vertical and radiating groups of small cells and nuclei; but the groups are broader, more regular, and together with the bundles of fibres between them, present a more distinctly fan-like arrangement. The sixth layer is again paler, and somewhat whitish, but contains some cells and nuclei which have a general resemblance to those of the preceding layers, and are arranged only in a faintly radiating manner. The seventh layer is of a reddish-gray colour of about the same depth as the preceding, and contains the same kind of cells and nuclei, but in much greater numbers, and mixed with some others of rather larger size. The eighth layer is the central white stem or axis of the convolution.

The investigations of Mr. Clarke in the minute structure of the cerebellum confirm, in the main, the observations of Gerlach.

Dr. Thudichum's case of wasting palsy is full of interest not only as a clinical study, but also on account of the remarkable manner in which the symptoms, manifested during the sickness of the patient, were explained by the anatomical lesions discovered after death. J. A. M.